TABLE 4.—*Summary of observations, showing temperature difference with height.*

	At 8 p. m.			At time of minimum temperature.		
Stations	1	8	7	1	8	7
Upper–lower:	°	°	°	°	°	°
Average difference	0.5	1.5	2.1	0.5	2.0	2.9
Largest difference	2	4	5	2	4	5

Three things are to be noticed: the smallness of the difference; the fact that the difference is greater at the time of the minimum temperature; and the fact that it is greatest at the coldest station. The largest average difference is only 2.9° and the actually largest value is only 5°. The difference is ordinarily supposed to be much larger than this. It is to be expected that the difference would be greater at the time of the minimum for the wind velocity is less. It is not altogether apparent why it should be greatest at the coldest station unless, as a valley station, it is more sheltered and the wind velocity is thus less.

OTHER RESULTS.

There are certain well-known and almost self-evident facts in connection with frosts, which need only be mentioned in passing. A still clear night is almost essential for a large drop in temperature and a consequent frost. Wind mixes the air and thus prevents the lower layer from cooling excessively, while a clear sky is essential for that free radiation from the ground which is one of the chief causes of the cooling. The wind was almost without exception northwest when a frost occurred; and frosts were found to occur on the first or second night following the passage of a "low," when the weather of the area studied was in transition to the control of an approaching area of high pressure.

It will be noticed that the dew-point at 8 p. m. was sometimes higher and sometimes lower than it was at the time of the maximum temperature in the afternoon. Either state of things can be readily explained. If there were no importation of drier air by the wind, the continual evaporation of water vapor from the ground and vegetation ought to add moisture to the air during the afternoon and thus raise the dew-point. The importation of drier air, however, is often sufficient to counteract the effects of this process and cause a drop in the dew-point.

Two processes operate to produce the cooling which may result in a frost. These are first, the importation of cooler air, and second, the radiation of heat from the ground and the cooling of the air next to it by conduction. It might seem that the cool nights during which frosts seem probable, could be divided into two groups depending upon whether the importation of cold air or radiation from the ground was playing the larger part in producing the cooling. This is, however, hardly practicable, because both processes are nearly always operative. On some occasions a strong northwest wind will import cool, dry air, thus holding down the maximum temperature during the day and causing a low dew-point. If the wind dies down during the night and the sky becomes clear, it takes but little radiation to cause a frost. On other occasions there seems to be but little importation of cool, dry air, the sky is very clear and there is almost no wind. Radiation is excessive and the resulting large drops in temperature may cause a frost. While both processes are usually active, it is generally easy to see which predominates.

SUMMARY.

The chief results and generalizations brought out in this study are summarized below. Of course these apply to Williamstown only, but the conclusions would probably be very similar for the whole of New England, and a similar set of data can be worked out for any place.

The so-called spring frosts may be expected from the last of April until the first of June and occur on still, clear nights, with the wind almost invariably from the northwest. They are likely to come on the first or second night following the passage of a low and the transition of the weather control to an area of high pressure. This facilitates both the importation of colder air and radiation, the two processes which cause the low temperatures required. The air is so dry and the dew-point lies so low that it plays no part whatever in determining the amount of the drop from the maximum to the following minimum. The drop is, however, far from a constant, and must be estimated for each individual case, taking into account the probable characteristics of the afternoon and night.

If, after the probable minimum temperature in the thermometer shelter has been estimated, it is desired to determine what the probable temperature of low-growing vegetation in the coldest part of the limited area will be, three things must be taken into account. First, that plant temperatures go below the real air temperatures, because the plants are in the open without such a hindrance to radiation as is the shelter about a thermometer; second, that vegetation is located near the ground and not at the height of the instruments in the shelter; third, that the variation in temperature over a limited area may amount to several degrees. Were this computation carried out with the average values for Williamstown, about 2° would be allowed for exposure in the open, 3° for height, and 6° for variation between the shelter and the coldest part of the area. Thus the temperature of vegetation in the open, near the ground, in the coldest part of the village may be expected to average 11° lower than the estimated minimum in the shelter as it is now located.

GOVERNMENT METEOROLOGICAL WORK IN BRAZIL.

By Prof. ROBERT DE C. WARD, Harvard University. Dated, Curityba, State of Parana, Brazil, August 6, 1908.

The following notes were made during a trip to Brazil in July and August, 1908, the object of which was to gather information, at first-hand, covering the climate, products, and development of that country. They are to be continued in the MONTHLY WEATHER REVIEW for September, 1908, where will also appear a map showing the location of the stations.

METEOROLOGY AT THE NATIONAL OBSERVATORY.

The National Astronomical Observatory at Rio de Janeiro, Brazil, is situated on the Morro do Castello, one of the hills overlooking the city, in a very densely populated section close to the harbor. The building was once part of an old Jesuit monastery, and is today extremely picturesque and interesting, with its *patio* filled with trees and shrubs; its rambling stone stair-cases and passage-ways; its quaint architecture, and the crowded population which surrounds it. The oldest church in Brazil, built in 1567, forms a part of the pile of buildings in which the observatory is now placed. Rumor says there are vast stores of hidden treasure in the hill, beneath the old monastery, and excavations have been made from time to time, in order to discover these riches, but so far without success.

The offices of the observatory are in the upper story of the building, and the instruments are placed at various points on the roof. The thermometers (wet and dry bulb) and thermographs are well exposed at the top of one of the principal towers. The shelter has a double roof, double louvered sides, and is large enough to walk about in.

In the main office, directly beneath this shelter, are placed the standard mercurial barometer (Fuess), and the self-recording instruments, which are of the usual Richard Frères patterns. There is also a new and quite inexpensive English self-recording anemometer, constructed on the pressure-tube plan. This instrument has not yet proved altogether satisfactory.

Outside, on the roof, three or four self-recording rain-gages are rather poorly exposed, being protected to some extent by higher portions of the building. The actual rainfall is taken to be the mean of the amounts registered by these gages. A Campbell-Stokes sunshine recorder is exposed at another point on the roof, and anemometers of several patterns are placed at the top of an open iron-work tower, rising well above the highest part of the roof.

The former Director, Dr. Luiz Cruls, died a few months ago, and the observatory is now in charge of Dr. H. Morize, formerly Doctor Cruls' assistant. The work is reported to be much hampered by lack of funds, and is at present chiefly meteorological. The astronomical work seems to be confined to the time-service, and to the regulation of chronometers belonging to the navy. A Bosch-Omori seismograph is installed at the observatory, and is giving satisfactory results. A new Wiechert seismograph, now at the grounds of the National Exposition, is to be placed on the observatory hill as soon as the exposition closes. It is Doctor Morize's intention to begin observations on atmospheric electricity at an early date, and he is now in correspondence with Dr. Leonard Weber, of Germany with reference to inaugurating a series of photometric observations at Rio de Janeiro. The meteorological observations in charge of the director of the observatory are independent of those made under the direction of the Navy, and of the Telegraph Department, referred to below, although the observatory publications frequently include results obtained at stations not under its own jurisdiction.

The publications of the Observatory of Rio de Janeiro are as follows:

1. Revista do Observatorio. Publicação mensal do Imperial Observatorio do Rio de Janeiro (1886–1891). This Revista, which was the continuation of the Boletim astronomico e meteorologico, published from 1881 to 1884, contained at first the monthly means for Rio de Janeiro, together with some brief and rather unreliable summaries for other stations. From August, 1889, to July, 1890, the Revista included the observations made at Greenwich noon at three stations.

(2) Boletim Mensal do Observatorio do Rio de Janeiro. The publication of this Boletim began in 1900. It contains meteorological and magnetic data more carefully discust, and set forth in better form than in the old Revista.

(3) Anuario publicado pelo Observatorio do Rio de Janeiro. The Anuario has appeared annually since 1885, when it began. It is the best known publication issued by the observatory, and contains, in addition to the astronomical tables for the year, occasional short meteorological discussions, and meteorological observations from different parts of Brazil as well as those made at the observatory. The latest volume of the Anuario (1908, XXIV), is a small octavo publication of 353 pages. It includes a large number of useful astronomical, physical, and meteorological tables. In the index, reference is made to page 354 for a "summary of meteorological observations made at the Rio Observatory and in some of the provinces [states] during the year 1906," but this summary was for some reason omitted entirely, the last page in the volume being 353.

As part of the work of the Observatory for Meteorology may be noted the publication, by the late director, Doctor Cruls, of a report entitled, Le climat de Rio de Janeiro d'après les observations méteorologiques faites pendant la période de 1851–1890 (Rio de Janeiro, 1891, in French and Portuguese). The matter herein contained was first published in the Revista do Observatorio, and the report was the first attempt to present a discussion of the climatology of Brazil. Altho the data at hand were insufficient to make possible anything like a complete treatment of the subject, the work presents many important generalizations. Mean annual temperatures and rainfalls, but no monthly means, are given. Doctor Morize has also published a report, in Portuguese and in French, on the climatology of Brazil (1891).

METEOROLOGY IN THE BRAZILIAN NAVY.

The most important meteorological work now being done by the Brazilian Government is that under the charge of the Navy Department.[1] The publications of this department include:

(1) Boletim dos Observaçôes Meteorológicas a 0^h de Greenwich ($9^h\ 07^m$ a. m. do Rio) e dos Rezultádos magnéticos, monthly.

(2) Boletim Semestral dos Rezultádos obtidos na Estação Central no Morro do Santa Antonio (Rio de Janeiro) e nos Estaçôes meteorológicas e pluviométricas, semiannually.

(3) Serviço Meteorológico Nacional, Boletim telegráfico diario, which is a daily weather map.

This department has also published Taboas meteorológicas, Rio de Janeiro, 1900, p. 89, large octavo. This set of tables is reprinted from a large volume of instructions entitled Instrucçôes Meteorològicas, Rio de Janeiro, 1900, p. 98, large octavo. Practically these instructions constitute a short text-book of meteorology, and hâve doubtless been very useful in stimulating the interest of the observers, as well as in giving them information of which they were not in possession. Unfortunately, however, the matter included in the volume is out of date in a good many cases, and somewhat misleading, as, e. g., in the case of Faye's cyclonic theory. The volume is divided into three parts, as follows: I. Meteorology and its subdivisions. II. Meteorological observations. III. Reduction tables. The longest section deals with atmospheric electricity and magnetism, as was perhaps natural in a work intended chiefly for the use of the navy. There is also a selection of weather proverbs, compiled from the list published some years ago by the U. S. Signal Service, most of which must be singularly out of place in Brazil.

The central station of the meteorological service of the Brazilian Navy is on the Morro do Santo Antonio, one of the hills of Rio de Janeiro, at an altitude of 64.5 meters above sea level. The instrumental equipment is as follows: Mercurial barometer, Kew pattern (Negretti and Zambra), reading in inches and in millimeters; a psychrometer; a Piche evaporometer; maximum and minimum thermometers; a rain-gage (Negretti and Zambra), having a diameter of 126 millimeters and standing 1.70 meters above the surface of the ground; a Redier mercurial barograph; a Richard thermograph; Capello anemographs; Fleuriais' anemometer, a modification of the Robinson pattern, recording the velocity in kilometers per hour by electrical contact whenever the observer closes the circuit; a Campbell-Stokes sunshine recorder. In addition to the central station at Rio de Janeiro, the Navy Department has[2] one first-order station (Curityba), which is really under the control of the Telegraph Department (see below); 21 second-order stations; 4 third-order stations, and 5 rainfall stations, making 31 in all. Of these about one-half are in charge of persons connected with the navy, while others are in charge of harbor commissions, telegraph officials, boards of health, directors of public works, etc. In location the stations range from Para (lat. 1° 28′ S., long. 48° 27′ W.) to Barra do Rio Grande do Sul (lat. 32° 09′ S., long. 52° 03′ W.) and from Manaos (lat. 3° 08′ S., long. 59° 59′ W.) to Parahiba (lat. 7° 06′ S., long. 34° 51′ W.).

The latest monthly Boletim (1896–1907 have been published) contains the observations made at Greenwich noon ($9^h\ 07^m$ a. m., Rio time) at the 31 stations above referred to, most of these

[1] Ministerio de Marinha. Repartição da Carta Maritima. Secção de Meteorologia.

[2] These figures are taken from the monthly Boletim for March, 1907 (Anno XII, No. 3, published in April, 1908), the latest number available during the writer's visit in Rio. There may have been some changes in the number and in the classification of the stations since then.

stations being directly on the coast. The record includes pressure, temperature (dry bulb and difference between dry and wet-bulb readings), relative humidity, vapor tension, cloudiness (kind and amount), general state of the weather, wind (direction and velocity on Beaufort scale), and remarks. The monthly means are also given. At the rainfall stations the daily observations are limited to wind direction and velocity, amount of cloud, general state of the weather, and precipitation. The Boletim also includes the results of magnetic observations made at the central station in Rio de Janeiro, and a map showing the magnetic variation for 1904 in different parts of Brazil, as determined by the first Brazilian magnetic survey.

The Boletim Semestral, of which sixteen numbers have been issued, was first published in 1898, and has grown from a small pamphlet to an octavo volume of somewhat over 1,000 pages. The last issue is No. 16, October, 1904, to March, 1905, dated Rio de Janeiro, 1907. This contains in full, the results of the observations at the several stations above referred to. The service is apparently growing in a healthy way. An inspection of the various stations, of which the details are given in the last Boletim Semestral, showed on the whole a satisfactory condition. It is hoped soon to be able to equip the coast steamers of the Brazilian Lloyd with meteorological instruments. One great difficulty now encountered is the delay of all publications which are printed at the Government Printing Office, and it is the intention of the Navy Department to establish, at the earliest possible moment, a printing plant of its own. The observations at the central station (Morro do Santo Antonio) in Rio de Janeiro are given hourly, the values for the night hours being taken from self-recording instruments, and include pressure, temperature, relative humidity, vapor tension, kind and amount of cloud (6 a. m.–11 p. m.), general weather conditions, character of precipitation (if any), optical and other phenomena, direction and velocity of the wind (Beaufort scale), frequency of different wind directions and velocities by hours, and a summary for each day, giving maximum and minimum temperatures, evaporation, and amount of rainfall. Monthly, six-months, and annual means are also given. For the second-order stations the observations are given in full for 9 a. m., noon, and 9 p. m., and are summarized for each month, for six months, and for the year. In the last number of the Boletim Semestral the number of stations given,[3] excluding Rio de Janeiro, is 8 second-order (three observations a day), 3 third-order stations (noon observation only), and 7 rainfall stations. The magnetic observations made at the central station are also included.

[*To be continued.*]

FURTHER OBSERVATIONS OF HALOS AND CORONAS.[1]

By M. E. T. Gheury. Dated Eltham, England, July 10, 1908.

On examining the results of the complete year of observations of halos, etc., I was struck by the fact that it shows that, while the failures are evenly distributed for all the phenomena except the solar halos, the latter exhibit very few failures and and seem a very good guide. Other particularities develop on examination. I therefore submit the observations for the last part of the year 1907 to complete the work already published in the Monthly Weather Review.[1] I do not think the further publication of other years' observations would be of much avail altho one year's complete record of halos, coronas, and rainfalls in England may prove interesting.

[3] At the end of 1904.

[1] Previous papers in this series appeared in the Monthly Weather Review, May, 1907, XXXV, p. 213; and December, 1907, XXXV, p. 579. The table accompanying closely follows in arrangement, abbreviations, etc., the tables of the previous papers.

Table 1.—*Observations of halos, coronas, etc., at Eltham, England, July-December, 1907.*

No.	Date and time of day, 1907.	Nature of phenomenon.	Previous minimum.	Previous maximum.	Mean barometer for preceding 24 hours.	Following minimum.	Following maximum.	Mean barometer for following 24 hours.	Weather at time of observation.	Weather during following 24 hours.	Description of phenomenon and general remarks.
1	2	3	4	5	6	7	8	9	10	11	12
			°C	°C	Inches.	°C	°C	Inches.			
53	July 1, 7:30 p. m.	Annulus, S.	9.2	15.7	29.69, rising from 29.64 to 29.74.	12.1	17.2	29.74, steady.....	Fine, cloudy, light wind.	Cloudy, rain........	With undefined edge, extending to 1 d.
54	July 2, 8 p. m.	Annulus, S.	12.1	17.2	29.74, steady......	8.2	17.5	29.60, falling from 29.73 to 29.45.	Fine, cloudy, windy.	Wet all day.	With undefined edge, extending to 1 d.
55	July 13, 10:30 a. m.	Corona, S...	10.3	20.2	30.08, falling from 30.15 to 30.04.	15.9	23.5	30.04, steady	Fine, cirro-cumuli veil.	Overcast, rain.......	Seen with biconvex lens; reddish, from 3 to 4 d.
56	July 13, 10:45 a. m.	Halo, S......	10.3	20.2	30.08, falling from 30.15 to 30.04.	15.9	23.5	30.04, steady......	Fine, overcast.......	Overcast, rain.......	Halo of 22°, reddish.
57	July 20, 7 p. m.	Annulus, S..	13.5	20.2	29.94, variable.....	13.6	21.9	29.91, falling from 29.94 to 29.83.	Fine, cloudy, still...	Overcast, hazy, very gloomy, distant thunder.	With undefined edge, extending to ¾ d.
58	July 21, 6 p. m.	Annulus, S..	13.6	21.9	29.91, falling from 29.94 to 29.83.	15.2	21.0	29.78, falling from 29.83 to 29.72.	Overcast, very gloomy.	Pouring rain........	With undefined edge, extending to 1 d.
59	July 25, 2 p. m.	Corona, S...	9.9	.....	.....	.....	.....	.....	Fine, cloudy, still...	Rapidly overcast, pouring rain.	Seen with biconvex lens; reddish, from 4 to 5 d.
60	July 26, 10 a. m.	Corona, S...	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Overcast, rising wind, showery.	Seen with biconvex lens; reddish, from 2½ to 3½ d.
61	July 27, 3:30 p. m.	Corona, S...	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Cloudy, windy, overcast, rain.	Seen with biconvex lens; orange and red, from 2 to 3 d.
62	July 29, 3 p. m.	Halo, S......	.....	.....	.....	.....	.....	.....	Fine, windy, cirri veil.	Overcast, strong wind.	Halo of 22°, inner edge orange, outer edge bluish; lasted 2 hours.
63	July 31, 7 p. m.	Annulus, S..	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Fine, very pure; cloudy, overcast, strong wind.	With undefined edge, intermittent, variable, extending to a distance from the limb varying from ½ to 1¾ d.
64	Aug. 1, 10:30 a. m.	Halo, S......	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Cloudy, overcast, strong wind.	Halo of 22°, inner edge reddish, outer edge bluish.
65	Aug. 2, 3 p. m.	Corona, S...	.....	.....	.....	.....	.....	.....	Fine, sun behind a very bright veil of pink cumuli, light wind.	Overcast, rain, and strong wind.	Seen with biconvex lens; reddish, from 1½ to 2½ d.
66	Aug. 4, 12:30 p. m.	Halo, S	.....	.....	.....	.....	.....	.....	Veiled sky, strong wind.	Overcast, strong wind, some rain.	Halo of 22°, pale orange.
67	Aug. 4, 5 p. m.	Rainbow, S.	.....	.....	.....	.....	.....	.....	.....	.....	Single, faint.
68	Aug. 16, 10 a. m.	Halo, S......	.....	.....	.....	.....	.....	.....	Fine, cirri veil......	Overcast, rain, gale.	Halo of 22°, inner edge orange, outer edge bluish.
69	Aug. 18, 8 p. m.	Corona, M..	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Strong wind, heavy squall of rain.	Reddish, from 2 to 3 d.
70	Aug. 18, 10 p. m.	Annulus, M.	.....	.....	.....	.....	.....	.....	Fine, light wind, sky apparently very pure.	Strong wind, heavy squall of rain.	With well-defined edge, from limb to 5′ distance round the gibbous moon, following exactly the shape of the illuminated portion; greenish, with a very narrow reddish edge 1′ in width; outside, a pale orange annulus with undefined edge, extending to ¾ d.